IDENTITY CRISIS

Is the Collapse of Law Enforcement's DNA Database Looming in the Future?

By Dan Bellini

Wailing sirens pierce the quiet summer night as police race to the scene of a reported homicide. Concerned family members called after finding the female victim alone and deceased in her apartment after she was not seen or heard from for several days. As the Detective Lieutenant surveyed the crime scene, he was quietly optimistic that he would have a name to connect to the suspect before too long, even though there were no witnesses or known suspects. The Crime Scene Investigators already informed him it appeared the victim had been sexually assaulted and they were able to collect biological material sufficient for DNA typing. The Lieutenant knew once he had a DNA profile, the identity of the responsible suspect was not far behind. Unfortunately, what he didn't know was the suspect used developing gene therapy technology to alter his DNA profile. As a result, rather than leading law enforcement to the true identity of the murder suspect, the DNA profile law enforcement would develop from the crime scene now matched one of a convicted felon who passed away two years ago while still in custody.

This scenario may sound like an excerpt from some futuristic science fiction novel, but what if it was possible for a person to change their DNA? Today, it is hard to imagine law enforcement investigations without the ability to analyze biological evidence and subsequently develop a DNA profile to assist in proving a person's guilt or innocence. The impact of DNA typing as a crime solving technique is so great; it is not unusual to hear some reference to it on a daily basis. Its influence and acceptance can easily be witnessed by watching any one of the numerous CSI shows on television each week and observing the frequency they refer to DNA evidence or DNA typing.

It is commonly accepted that everyone has a unique DNA sequence, a sequence that is identical in every cell within their body; one that is constant from birth until death. This premise is the basis of law enforcement's use of DNA typing as a means of tying subjects to crime scenes involving biological evidence. DNA collected from a suspect by law enforcement either through a blood sample or buccal swab can be used to develop the suspect's DNA profile and since a person's DNA sequence is constant, this DNA profile will match the DNA profile developed from bodily fluids the suspect left at a crime scene even if that sample was collected years later. However, if a person's DNA sequence could strategically be changed, the entire foundation upon which law enforcement relies on DNA evidence would crumble. As you will read, in the emerging future, developing gene therapy technology will enable a person to change their DNA sequence.

Simply put, DNA typing is the biometric identification of a person obtained by examining their unique sequence of DNA base pairs.[1] The scientific community and the courts consider the actual technology of DNA typing unquestionably sound and reliable (*U.S. v. Jakobetz* 1992).[2] Any adverse issues that have arisen in the courts regarding DNA typing have been attributed to either the actual collection of biological evidence at the crime scene (issues of contamination) or in the presentation of the evidence to the jury in such a manner that it could be understood. The infamous O.J. Simpson trial demonstrated both of these problems; however, at no time during that trial was the actual reliability of DNA typing as a process questioned. On a larger scale, as we will discuss, the impact of DNA has been dramatic and pervasive in our justice system. Any threat to the reliability of this "tool for truth" might set prosecutions back at least fifty years.

HISTORY OF DNA TYPING

In 1953, the world of molecular genetics changed when two scientists, James Watson and Francis Crick, discovered the DNA double helix structure.[3] The structure of DNA is the same throughout all organisms (plants, animals and microorganisms), but due to the order of the DNA base pairs, each individual organism looks different. In humans, 99.9 percent of the DNA sequence is identical amongst individuals, while only one tenth of one percent differs.[4] This not only explains why all humans look like humans and not some other plant or animal, but it also makes each person unique.

Even though one tenth of one percent of the DNA sequences differ from person to person, every cell within the same person contains the exact same sequence of DNA. Therefore, a person's hair, blood, and skin cells are unique to that individual and exactly the same at the molecular level. This is beneficial when law enforcement is investigating a crime. If a person leaves a strand of hair, a drop of blood or any other cells at a crime scene, law enforcement can collect the evidence for DNA analysis.

DNA is composed of four repeating molecules or nucleotides, Adenine, Thymine, Guanine, and Cytosine.[5] These molecules are linked together in long chains to spell out the genetic code, or genes, which tell cells what to do. Each gene is composed of a different arrangement of these same four molecules and this "code" is translated into a specific protein. Any change or mutation that occurs within the coding region of a gene, thus creating variability between individuals, is often detrimental to the organism since there is a high probability that the mutation would affect the functionality of the protein. This is why genes critical to the survival of an organism are highly conserved. However, not all of our DNA codes for genes or contains useful information. A portion of our DNA is "non-coding" or "junk" DNA which is not translated into useful proteins. Changes or mutations often appear and remain within these regions of junk DNA as often as once in every 200 bases because they don't affect the health or survival of the organism.[6] DNA typing often focuses on the DNA sequences within these non-coding regions since these regions are highly variable between individuals.

The human genome contains about 3 billion base pairs of nucleotides.[7] To try to sequence this much DNA to determine the differences between individuals would be extremely time consuming and expensive. DNA typing allows differences between individual's DNA to be seen in a visible pattern without having to actually sequence the DNA. In 1985, Alec Jeffreys and his colleagues at Leicester University, used restriction enzymes and gel electrophoresis to develop the first DNA profiles.[8] They referred to these techniques as "DNA fingerprinting". Today, the most prevalent analysis method for determining DNA profiles is through the use of Short Tandem Repeat (STR) analysis. STR's are DNA sequences ranging from two to eight base pairs in length that are repeated in tandem. For example, the STR locus D5S818 consists of a four nucleotide sequence "AGAT" that is repeated anywhere from seven to fifteen times.[9] The number of repeats at any given STR locus can vary from person to person and it is these differences that are used to distinguish between individuals. STR's are typically located in the non-coding region of the DNA and there are currently over 10,000 different STR loci identified in the human genome.[10] Thirteen standard STR loci are used by the Federal Bureau of Investigation (FBI) for the Combined DNA Index System (CODIS).[11] CODIS is a software program that operates local, state, and national databases of DNA profiles from convicted offenders, unsolved crime scene evidence, and missing persons.

DEVELOPING GENE THERAPY TECHNOLOGY

Gene therapy is a technique developed for correcting genes that are defective and as a result of the defect, cause a genetic disorder.[12] Genes that are defective either produce a defective protein or produce no protein at all. The goal of gene therapy is to either fix the defective gene or replace it completely thus generating a functional protein and correcting the disorder.

Gene Therapy techniques involve delivering and inserting DNA into a person's cells to restore normal gene function. To accomplish this, a carrier molecule referred to as a vector is used. There are two types of vectors used, viral and non-viral. Currently, a virus that has been genetically altered so it can carry human DNA is the most common vector. When using a viral vector, scientists take advantage of the virus' natural ability to enter a cell and transport genetic material to the cell's nucleus.[13] Scientists alter the virus' genome to remove its disease causing DNA and then insert the specific normal human gene they want to deliver and insert into the person's cells. The altered virus infects the person's target cells and then unloads its DNA, which contains the normal human gene. The normal gene can now generate a functional protein which will restore the cell to a normal state.[14]

Once the type of carrier molecule or vector has been chosen and altered, the vector must be delivered to the cells targeted to receive the altered gene. There are several methods for delivering the vector to the target cells. There is systemic delivery and local delivery.[15] Systemic delivery is used when the target cells cannot be reached. The vector is injected into the person's bloodstream thereby reaching millions of cells throughout the person's body. Local delivery can be either ex vivo or in vivo. Ex vivo is when the target cells are removed from the person's body and then exposed to the vector before being reinserted into the person's body. In vivo consists of injecting the target cell area directly with the vector.

Gene therapy clinical trials have been completed with mixed results and numerous genes are currently being tested for use in gene therapy. Some examples are the gene for treatment of cystic fibrosis, genes responsible for hemophilia, genes that can help in heart failure, and genes that stimulate the growth of new blood vessels.[16] Although gene therapy is still experimental and the Food and Drug Administration (FDA) has not approved any human gene therapy product for sale in the United States, other countries are not as hesitant. The most recent advance in gene therapy was just reported in September 2005 when China approved Gendicine, a recombinant adenovirus encoding human p53 tumor suppressor gene for the treatment of head and neck cancer. Gendicine delivers a normal p53 gene, packaged in a non-pathogenic adenovirus that infects tumor cells and replaces the mutated form of the p53 gene present in the tumor.[17]

IMPACT OF GENE THERAPY ON LAW ENFORCEMENT'S DNA DATABASE

What is the connection between gene therapy and DNA profiles? Up to this point, these two sciences have had no impact on each other. However, advances in gene therapy technology will make it easier, more efficient, and cheaper to alter a person's DNA sequence.

In May 2005, a professor at the Royal Free Hospital in London was working on using gene therapy to help sufferers of muscular dystrophy.[18] The therapy, which involves injecting genetic material that codes for a protein called Mechano Growth Factor, was successful when tested in mice to boost muscle mass and dramatically increase muscle strength. Professor Sweeney at the University of Pennsylvania was working on a similar project using gene therapy with a different gene and it was expected that a human trial would likely occur within the next year.[19] Doctors fear that this advancement will have a serious impact on the sporting world with athletes using the procedure to enhance performance. Professor Sweeney stated that "Once you start testing on humans, you'll get rogue doctors in certain countries offering this thing for profit. There's simply too much money to be made".[20]

The Seattle Times polled 25 experts regarding gene doping in sports. A handful of the experts believe someone in the athletic world has already tried gene doping and some experts believe gene therapy will be abused by the 2008 Olympics.[21] According to Doctors, the procedure is so simple and widespread that a trained college biology student could perform gene transfers; it's not something that is very hard to do.[22]

Lentigen, a Baltimore based company, started a web site in November, 2005 for ordering a vector custom made to a customer's specifications containing the DNA sequence of their choice.[23] The customer only needs to indicate the DNA sequence they desire the vector to contain. For under $2000, the company will manufacture the custom vector to high purity and provide a vial of the vector. Additional vials can be purchased for $500. The Lentigen vectors are safe for human clinical trials and the company takes all major credit cards. This removes any hurdles that development of a vector containing the proper DNA sequence would have presented and makes it that much easier for those who are interested in using gene therapy technology for inappropriate means.

The growing power of DNA typing and the ability for law enforcement to recover useable samples for DNA analysis from smoked cigarettes, the back of stamps, the flaps of envelopes, discarded hats, soda cans, inside latex gloves, or even from fingerprints left at a crime scene, will result in people looking for ways to avoid identification. The thirteen standard STR loci used by law enforcement to develop DNA profiles aren't secret; a quick search of the internet will reveal the thirteen STR loci. Just imagine if gene therapy technology was utilized to develop a vector to alter the nucleotide sequence at just one of these standard STR loci and thus alter the appearance of the DNA profile. For example, since the STR locus D5S818 consists of a four nucleotide sequence that is repeated seven to fifteen times, a person would only need to alter the number of times the four nucleotide sequence is repeated to alter their DNA profile. Given that STR sites are located within a non-coding region of the genome, a region which is not translated into useful proteins and makes no contribution to the health or survival of the organism[24], it could be possible to change the DNA sequence enough to alter the DNA profile without affecting the person's health.

An identification made from DNA evidence is based on the probability that a given DNA profile exists in the population. This probability is established from population genetic studies. Using the thirteen STR loci, the probability that two people will have the same DNA profile can be as high as 1: 1 billion.[25] Once one person is able to change their DNA sequence in a manner that results in a subsquent change to their DNA profile, scientists will be unable to predict how common a given DNA profile is in the population. If a person is arrested based on a DNA profile developed from biological evidence at a crime scene, who is to say the biological material wasn't left by another individual who had undergone gene therapy? Law enforcement will be unable to rely on DNA evidence as a source of identification.

One might suggest that currently DNA plays a supportive role in the criminal justice system; that criminal cases are not made solely based on DNA evidence. Although it could be argued that DNA plays a supportive role, there are many cases where the other evidence is circumstantial and if it were not for the DNA evidence the case could not be prosecuted successfully. Take, for example, the evidence presented in the case of the People versus O.J. Simpson.

In the Simpson prosecution, all evidence except the DNA samples were circumstantial. The history of violence directed at his ex-wife, the hairs consistent with Simpson found on Ron Goldman's shirt, the cotton fibers consistent with the carpet of Simpson's Bronco found on the cap at the Bundy residence, the fresh cut to Simpson's hand, the shoe print found at the Bundy residence which was consistent with the style and size Simpson wore, and Simpson's flight from law enforcement and subsequent capture with over $8000.00 in cash, a disguise, and his passport, were presented to show evidence of guilt, although none were the proverbial "smoking gun."[26] Simpson was not convicted despite the overwhelming circumstantial evidence against him, in part, because the jury did not place value in the DNA evidence. Although "reasonable doubt" regarding the DNA evidence came from the suspicion the biological evidence was contaminated or planted, this is still a perfect example of the important role DNA evidence plays in the criminal justice system and the resulting effects once the value of DNA evidence is reduced. If scientists are unable to predict how common a given DNA profile is in the population, DNA will only be as valuable as the old ABO blood typing evidence. Because the probability of an individual in the United States having a given ABO blood type can range from one percent up to thirty-eight percent,[27] "....the test is not very useful when an inclusion has been made".[28]

As mentioned earlier, there have been adverse issues that have arisen in the courts regarding DNA typing that have been attributed to the actual collection of biological evidence at the crime scene (issues of contamination/planting). It may seem the threat these issues present to the successful use of DNA evidence in court is being ignored in this article, however, these issues can be easily overcome by law enforcement through proper scene documentation and evidence collection procedures. Additionally, when present, these issues only jeopardize the current case and do not present a threat to the entire DNA database. Even if the scope of altering one's genetic fingerprint is nominal today, the devastating impact of a mere handful of misidentifications due to the use of this technology warrants the time and money necessary to counter the threat before it emerges.

FUTURE OF DNA TYPING

The U.S. Food and Drug Administration (FDA) is the primary government agency responsible to protect the health of U.S. citizens. The FDA is responsible to ensure gene therapy products are high quality and safe and are properly studied in human subjects. The National Institute of Health (NIH) is responsible to evaluate the quality of the science involved in gene therapy research and focuses on the scientific, safety, and ethical issues involved in the research.[29] The NIH established the Recombinant DNA Advisory Committee (RAC) to develop guidelines to govern the safe conduct of research.[30] Unfortunately, compliance with NIH guidelines is only mandatory for institutions receiving NIH funds for research.

A 2000 study found there was a lack of adherence by University researchers to existing RAC and FDA recommendations. In fact, less than five percent of the reporting required to NIH was completed.[31] History has demonstrated that simply trying to regulate gene therapy research and products won't prevent the misuse of gene therapy technology. An example is the doctor at UCLA who, after being denied permission to test a gene therapy product in Los Angeles, proceeded to test the product on patients in Italy and Israel.[32] It is therefore incumbent that alternative safeguards be developed to protect law enforcement's DNA database.

These safeguards may include developing new technology to detect when changes to a person's DNA sequence have been made, developing new markers for use in analyzing DNA profiles, or mandating routine periodic DNA sampling to detect when a person has altered their DNA. Regardless of the solution, it is likely that resolving the potential threat to law enforcement's DNA database will require years of laboratory research and may require enacting new legislation. For these reasons, it is imperative that the criminal justice system recognize the fragility of the DNA database now and take the lead to develop the protective measures necessary to ensure law enforcement's ability to rely upon DNA typing as a valuable crime solving tool.

CONCLUSION

Currently, DNA typing is common throughout law enforcement. The general public and those in the criminal justice system have come to expect its use in cases involving biological evidence. DNA typing has been widely accepted as being built on sound science. This science is based on the knowledge that every person has a unique DNA sequence; a sequence that, up to now, remained the same throughout a person's life and could not be changed. But developing gene therapy technology may very well change this accepted truth. Soon, a person may have the ability to strategically alter their DNA sequence thus altering their DNA profile. If this were to occur, law enforcement's DNA database would be completely undermined.

The use of DNA profiles is an invaluable tool, not only to law enforcement as a crime solving tool, but also to the entire criminal justice system as a tool that can be used to exonerate those who are falsely accused of a crime. There is a critical need for law enforcement leaders to be progressive and innovative to address gene therapy's potential impact on law enforcement's DNA database. Will law enforcement respond in time to safeguard the DNA database? Or will we be content to standby and idly watch as the database becomes just another piece of invaluable information? You decide.

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